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DEPARTMENT OF SUMMARIES

TO BE DEVOTED TO DIGESTS OF PROGRESS IN BIOLOGY

While the *Transactions* will continue to be primarily a Journal of research in micro-biology, it is recognized that the field has become so broad as to preclude the possibility of frequent articles in any one of the departments of special interest. Because of this it will be the policy to present, from time to time, supplementary digests of the progress being made in the various fields of micro-biology. It is also proposed to introduce similar summaries of the progress made in some departments not represented in our articles of research. This is done with the feeling that such reviews will increase the permanent value of the *Transactions* to all who may not have access to a large list of technical biological journals, nor the time to make the survey for themselves.

PROGRESS IN EVOLUTIONARY THOUGHT

SOME LATTER-DAY ASPECTS OF "DARWINISM."

BY J. F. ABBOTT.

A lecture given before the faculty and students of Washington University Jan. 9, 1912.

If any one thing can be taken as a symbol of the present time, I fancy the most appropriate would be the hammer. Not only is the hammer the symbol of constructive industry so characteristic of our age, but it may also typify the spirit of iconoclasm, which is equally, if not more strikingly, characteristic. From the muck-raking of a popular magazine to the calm, deliberate, destructive criticism of a system of philosophy, now is essentially a time of making over. The present generation has no reverence for traditions of the past unless they be in harmony with the point of view of the present.

It is by some considered a sort of poetic justice that the image of the greatest iconoclast of modern times, in effect if not in purpose,—Charles Darwin,—should be torn from its pedestal by those upon whose shoulders his mantle of leadership in Biology has fallen.

For in spite of the fact that the theory of evolution is far wider than Darwin's hypothesis of Natural Selection, and that Darwin's theories were anticipated in many ways by Maupertius and others; in spite of the fact, too, that Darwin's own personality was the opposite of aggressive, the fact remains that Darwin's name stands as the personification of that intellectual insurgency which shattered

the placid conventions of centuries, and although Darwin himself, without question, worked with an eye "single to the pursuit of truth" for its own sake, yet the publication of "The Origin of Species" in 1859, like an absent-minded prod of an ant hill with a walking stick, instantly set up a commotion which took decades to subside.

Like a spark in prairie grass in the autumn, the fire of the idea at once spread in all directions, biological interpretations of history, of philosophy, of psychology, of economics, of astronomy, sociology, of pedagogy soon became the order of the day and the world was apparently fully persuaded to the new way of thinking.

This had little to do, perhaps, with the "origin of species" as such. What, then was the significant kernel of Darwin's speculations that was so fruitful of growth and so capable of transformation?

Briefly, it was this,—the substitution of a natural for a supernatural explanation of the material organic universe. It was this that aroused the united wrath and enmity of the Church and engendered the bitter disputes which occupied the sixties and seventies.

To Darwin more than to any one else, perhaps, was this directed, for, while evolution was in the air not only throughout the 19th century, but during the larger part of the 18th as well, and although biology came into the debate comparatively late, yet the polemic ability of Huxley and the imperturable materialism of Darwin combined to draw upon the biologists all the theological lightnings with which the sky was charged.

The "anthropocentric" conception of man as the center and chief factor in a universe created for his especial use and enjoyment was decidedly a hard one to forego, and in spite of the gradual acceptance of the evolutionary standpoint during the latter half of the century past, there has always been a small remnant, silenced but unconvinced, whose recantation has been much like the famous one of Galileo.

Biologists have discovered that the fundamental characteristic of living matter, by virtue of which it is alive, is mutability, and that stability is synonymous with death. It is not otherwise with hypotheses or with ideas. So long as they retain the vital spark we must expect their nature to be at least susceptible of change. When

an hypothesis has passed this stage, it is no longer a working basis, but has become a creed.

Darwin's theory of "Natural Selection", announced a half century ago, struggling for recognition, and finally achieving it, has been no exception, and the addition of new facts, the assembling of a mass of data, beside which even Darwin's patient and painstaking accumulation seems insignificant, could not otherwise than alter our point of view. To those, however, to whom the indefinite is abhorrent and who find a certain soul-satisfaction in a rigid creed, the calling into question, on the part of biologists, of some of the fundamentals of Darwinism has been hailed as a tardy renunciation of heresy, for which the only alternative is a reversion to first principles.

One of the curious consequences, then, of the increase in interest and knowledge along evolutionary lines has been a recrudescence of what may be called anti-Darwinism literature, and this has been not alone the product of hidebound conservatives. Among biologists there have not been lacking those who feel that Darwinism has had its day and have hailed with satisfaction various subsidiary hypotheses as "new theories of evolution." It is not to be wondered at, then, if the layman is somewhat puzzled, and doubtful of what he should think or believe.

In most people's minds the primary difficulty, perhaps, is in the confusion of two radically different conceptions—Evolution and Darwinism. These are not synonymous terms. Evolution would, perhaps, have been the philosophical basis of modern thought even if Darwin had never lived, and the refutation of the whole principle of natural selection would not alter in the slightest the theory of evolution as such, since Darwinism is but one of several possible explanations for an evolution otherwise conceded to exist.

Darwinism, then, must stand or fall on its merits, and if it falls we must seek some other explanation of the method of evolution.

To deal adequately with the history of the Theory of Evolution, even if details be omitted, would require not a lecture hour, but a semester course. One point, however, needs a word of comment.

Since the mind of man first began to ferment and ideas other than those of food and shelter rose to the surface, two aspects of

nature have claimed his attention, one the *static*—dealing with things as they are, always have been and presumably always shall be—the other, the *dynamic*, that recognizes the apparent stability of nature to be illusory and that, to quote a familiar phrase,—“the only stable thing in the cosmos is the fact of change.”

The latter was more especially the trend of earlier thinking, the former was set and crystallized by the influence of the mediæval church, and it was because scientific progress in the 19th century again brought men around to the dynamic point of view that the inevitable clash occurred between ecclesiastical dogma and scientific speculation.

It is well to keep clearly in mind the implications of these two points of view, for they are mutually exclusive, and to try to combine them is to invite mental anarchy. To think of the Universe (by which is usually meant that atom of it called earth) as a stable something, unchanging in its physical aspects, permanent in its organic types or species and immutable in the intrinsic nature of what we call human spirit or soul,—that is one thing. To conceive of the Universe, physical and spiritual, as a constant flux, in which matter has no stability in form (if in substance), where time and space are but artificial concepts of the human mind, that is quite another. Let there be added to this constant changefulness of things the concomitant of law and order and we have the evolutionary standpoint. The other is the concept of special creation, which was characteristic of the mental attitude of Europe (with certain exceptions) until the middle of the last century. The former has been the characteristic point of view since. The “Origin of Species” stands at the dividing line, for although it would be quite incorrect to assert that this book was the *cause* of the change in the point of view of the western world, yet, like a burning glass, it certainly focused the various divergent rays of evolutionary thought and brought to a blaze the smoldering fires of opposition to the established order of thought. It offered a mechanical explanation of the evolutionary process in the organic world and demanded no superphysical agencies to bring it about. Herein was its great and novel strength and also, as we shall see, its weakness.

It has seemed worth while, therefore, to review the standpoint of the Darwinian Theory in the light of present day advances and

try to discover just where we stand, since the adage that "where there is so much smoke there must be fire" is not without its empirical justification. Since the greatest danger in such an exposition is that of discursiveness, I shall try to confine myself pretty closely to my topic. I shall not take time to discuss Evolution in its broader aspects, either historically or analytically. I shall take it for granted that you are all Evolutionists in this general sense. If any one truly believes that Adam and Eve are historical characters and that the Mosaic account of the Creation is anything more than a childish tale, suitable for childish minds, I take no issue with him. I merely do not understand the workings of his mind, nor, I fancy, will he of mine.

The outlines of the Darwinian Theory are no doubt familiar to most of you, but it may not be out of place to review them, since unless we understand perfectly what the original hypothesis is we are hardly in a position to appreciate criticisms of it.

The first thing that strikes the attention of the naturalist in the field is the astounding prodigality of Nature,—the wasteful largesse of individuals,—of life itself.

"Nature", to quote Tennyson,

So careful of the type she seems,
So careless of the single life,
That I, considering everywhere
Her secret meaning in her deeds,
And finding that of fifty seeds
She often brings but one to bear.

The poet did not avail himself of his poetic license in limiting the number to fifty. The more prosaic minded scientist knows that fifty myriads would more nearly approach the fact.

A few examples will make this clear. We learn that an eel may lay 15,000,000 eggs, the oyster $\frac{1}{2}$ to 16 million, the codfish 60 million. Yet if any considerable number of any species survive, these huge numbers would seem unnecessary. Let us take as an extreme example the hypothetical case of an annual plant producing two seeds only. If each seed sprouted and survived, at the end of twenty-one years there would be 1,048,576 plants! Jordan estimates that if all the fly eggs laid in a single day in a large city should actually hatch out, the inhabitants of the city where this happened could not

escape in time to avoid being smothered by the mass of hatching flies. The common mosquito completes its life cycle in about ten days. Each female lays 200-400 eggs. Let us take the minimum number, 200. If one half of these are females there will be 100 left as the first generation. It is a startling problem in arithmetic to figure out how many mosquitos a single summer would produce if all survived. We see at once that it is not the ratio of increase that is significant, but the ratio of *net* increase, which is a very different thing. Out of the hosts of individuals born into existence only a few survive each time, and a constant balance is maintained. When this balance is disturbed, as in the case of the importation of rabbits into Australia, we have a startling instance of the unchecked productivity of Nature. The question now comes up,—“Are those individuals that survive merely the lucky beneficiaries of chance and has their selection been indiscriminate, or has there been some criterion of selection, some standard attained, that Nature permits them to survive and propagate their kind?” The Darwinians hold to the latter view, and this second step in the hypothesis now demands examination.

Conceding this elimination to be an indisputable fact, what is the basis for the postulated selection? We recognize that variation is universal, but few except the naturalist have any idea *how* universal it is, how all-pervading, affecting not only form and structure, color, etc., but habits and physiological traits, invisible, but very significant withal. Another thing about these variations, which have been called fortuitous or chance variations, to distinguish them from other kinds, to be mentioned later, is the very important fact that they are susceptible of mathematical treatment, i. e., may be studied quantitatively instead of qualitatively, which is a great advance. If I shake the dice out of the box a thousand times, although I can never predict just what any one throw will be, yet I can figure out very exactly, by the Law of Chance, just how many of one combination will turn up out of the whole lot. In the same way the insurance actuary, although he may not have any second sight as to when I shall die, yet knows to a fraction just how many men of my age out of every thousand are going to die during the next twelve months. In the same way, although I cannot tell just how many rays any one daisy may have, yet out of a thousand I can tell how

many will have 12 rays, how many 21, and how many 40. For we have learned that the greater number of variants are found about the middle dimension, the mean, and the farther away we get from such a mean the fewer examples we find out of a thousand, so that of the lowest and highest extreme there may be only one or two. We may plot these dimensions in a curve, and when we do so we find that the curve is of the class known to mathematicians as the "binominal curve."

Now another aspect of existence claims attention. In spite of this all pervading variability, men and dogs and oak trees are all pretty much like other men, dogs and oaks. Particularly they are much like their immediate ancestors,—a resemblance which we recognize by the term Heredity. Heredity and variation are but two sides of the medal. Comparing an individual with its ancestor we see that there are many points of similarity. These we class as hereditary, the balance of dissimilarity we call variation. It must be kept in mind that neither of these terms stand for concrete things, but only for relations,—comparisons, as a matter of fact. In the relative proportion of these two constituents,—the warp and woof of the individual fabric,—there enters another and significant factor.

Ole Olson, here, resembles his mother so closely that any one's attention is attracted at once to the phenomenon. His brothers and sisters are all apparently cast in the same mould. His uncles and aunts bear a family resemblance, his great grandfather perhaps less of a one, but altogether they class themselves first as Olesons, next as Scandinavians, then as Europeans, then as Caucasians, then as human beings. The native of Russia or of sunny Italy is also a European and a Caucasian, although not even a child would think of calling him a member of the Oleson family. Wu Ting Fang is a human being as well, although no disguise could make one mistake him for a European. It needs no argument to prove that the reason the Olesons look alike is that they are of one family. The reason they are unlike Caruso is that they are more remotely related, but that both Oleson and Caruso look more alike than they resemble Wu Ting Fang is but other evidence for what we know already,—that they are related to each other much more closely than either of them to the Mongolian. In other words, individuals resemble each other largely in direct proportion to the closeness of their re-

lation,—a rule that works both ways, for, as we say, “like begets like”.

Acting on this belief, Darwin claimed that since in the struggle for existence the best adapted survive, and survive on account of possessing, accidentally, as it were, certain favorable variations, then these very variations, like begetting like, would not only perpetuate themselves, but would become intensified generation after generation. Now, not only the organic but also the inorganic universe is in a constant state of flux. The “rock-ribbed hills” are as transitory as the April snowflake in the eye of Him for whom time does not exist. If the environment were constant it would not matter whether a species varied or not. But with a changing environment, the perpetuation of selected types, based on appropriately favorable variations, permits of a flexible adjustment of the specific type to the new conditions; in other words, the formation of a new type or species. This is the *Origin of Species* according to Darwin.

Let us, at the risk of being tedious, give a brief summary of this train of thought.

Given, first, the fact, which is undeniable, that of every type of animal or plant there are born into existence an infinitely greater number than can possibly find food or room to exist in, and we have as a corollary, that of this multitude, only a few can survive to propagate the series—this is the famous “Struggle for Existence”.

Given, in the second place, the fact, now a thousandfold more emphasized than in Darwin’s time, that every individual animal or plant, and indeed every part of an individual, is subject to variation within limits, so that there is never such a thing as a duplicate in nature; combine this variation with the fact of heredity, which implies that the progeny are, as a rule, more nearly like the parents than they are like anything else, and we have a basis for elimination, i. e., those individuals in the struggle for existence whose variations are such as to lend even a slight advantage in that struggle are the ones who will survive and thus bring about the “Survival of the Fittest.”

Given, in the third place, the survival of the fittest, and combine with it a changing environment such that those characters, once of advantage, become less advantageous than other characters produced by this same variation, and we have through the constant

elimination, in the never ceasing struggle for existence, the establishment of a new type adapted in this way to the new environment, but one adapted, remaining fixed and only subject to elimination in conflict with other types better adapted.

Such in outline is the essence of Darwinism,—a mechanical theory of the origin of species through the elimination of the unfit and the survival of the fittest to propagate their kind. The words “Natural Selection” were used by Darwin in the belief that essentially the same process takes place in nature that the plant or animal breeder uses, in selecting for breeding those individuals that conform to an ideal type.

The latter-day opponents of Darwinism may be divided into two groups: those who deny in toto that there is such a thing as the natural selection to which I have referred; and those who, while accepting the existence of such a factor, yet deny its universal application, and in particular deny its function in the formation of new species, offering in its place substitutionary or emendatory theories. The former are truly destructive critics to be refuted or accepted. The others offer something else which must be considered. To the former group belong such men as Dennert¹, Fleischman², Wolff³, and Driesch. In the second group may be included De Vries⁴, Delage⁵, Eimer⁶, and Morgan⁷.

To use a rather trite comparison, the chain of steps involved in the uprearing of a theory is no stronger than its weakest link. Any one fact disproved, or any one deduction shown to be inconsequent, straightway reduces the theory builded on that fact or deduction to the rack of an unproved speculation.

For the opponents of the natural selection theory to show that any fact of nature is inexplicable on the basis of that theory is to shatter the whole hypothesis, since as a comprehensive explanation of the method of evolution, Darwinism must be all or nothing. That there are such inexplicable facts is believed by many biologists,

1. E. Dennert, *Vom Sterbelager des Darwinismus*, 1903.

2. A. Fleischman, *Die Descendenz-Theorie*, 1901.

3. G. Wolff, *Beiträge zur Kritik der Darwin'schen Lehre*, 1898; *Der Gegenwärtige Stand des Darwinismus*, 1896.

4. H. De Vries, *Die Mutationslehre*, 1901.

5. Y. Delage, *L'Heredite*, 1903.

6. Th. Eimer, *Orthogenesis der Schmetterlinge*, 1897.

7. T. H. Morgan, *Evolution and Adaptation*.

though it does not of necessity follow, as some have thought, that because the all-sufficiency of the hypothesis may have been controverted, its all-importance as a significant factor in the argument can be left out of consideration.

Briefly summarizing the points that have been made against the natural selection theory we may note, first, the insignificance of fluctuating variations, such that they can have no possible selective value. For example, Kellogg⁸ mentions the fact that the white pelt of polar bears is of very great aid in securing food, but that it is almost impossible to conceive that the few white hairs on an originally darker ground could have had any selective value or could have played any part in the struggle for existence between such a bear and a normal one. Herbert Spencer⁹ calls attention to the fact that a certain Greenland right whale weighing about 44,800 pounds had femurs weighing together three and a half ounces, "while a sample of the razorback whale (*Balonoptera musculus*) 50 feet long, and estimated to weigh 56,000 pounds, had rudimentary femurs weighing together one ounce; so that these vanishing remnants of hind-limbs weighed but one 896,000th part of the animal." It is indeed questionable whether the advantage or disadvantage in nourishment or weight accruing to the whale with the two-ounce femur in comparison with one, let us say, with a four-ounce femur would be significant in the struggle for existence. Yet according to Darwin's hypothesis, there would be no possible method for developing such a condition except through the elimination of individuals having a less well-adapted structure. This objection naturally occurred to Darwin, but he believed that in the intense struggle for existence even the minutest differences would be significant in determining which should survive; and later biologists have had their attention attracted to the fact of correlation in variation, by virtue of which characters of no significance in themselves are linked, as it were, with other characters which have selective value. These characters might often be physiological and hence invisible, but of none the less significance in the life and activities of the creature possessing them.

A second point well made is the inutility of many specific characters. For example, one of the largest groups of beetles, the

8. L. Kellogg, *Darwinism To-day*, 1907.

9. A Rejoinder to Professor Weismann, *Contemporary Review*, Sept., 1893.

Carabidæ, is divided into two special groups by the practically invariable character of the presence of two microscopic hairs over the eye, or of only one such hair. The scientific imagination is embarrassed in an attempt to read utility into any such character as this. The same is true of many color markings, notably in those molluscs whose beautiful color markings are covered by the mantle and visible only when the animal is dead and the shell cleaned. The answer made to this objection is that many characters now useless have been useful at some earlier stage in phylogeny and have lost their function through change of habit. The specious argument is also often heard that it is not for mere man to decide what is useful or not to an organism far removed from his own experience.

A third important point is found in the fact, easily demonstrated, that according to Quatelet's law, the extreme variants are always fewest in number. These extreme variations would be the ones of most value in selection, but it is hard to see how they could help being swamped out in promiscuous mating and brought back to average mediocrity, because of the fewness of their numbers, since the chance of their mating together and thus perpetuating the variation is infinitely smaller than that of losing the advantage by mating with an individual without the variation.

Fourth, in the same connection, although Darwin's hypothesis is based entirely on chance variations, it is almost absurd to believe that advantageous variations should occur in many individuals at the same time; yet, to have any effect on the mass, this fortuitous variation in a given direction is a necessity to assume. For example, in bilaterally symmetrical animals it has been found that the index of variability in the right and left sides is very often quite different, yet the purely mechanical theory of natural selection is asked to explain how, for example, two eyes that focus together may arise in conformity with the law of chance. The pro-Darwinians, who try to answer this objection at all, are obliged to call upon some new supporting hypothesis, such as orthogenesis or directive variation, which is a very different thing from Darwin's fortuitous variations.

Another very potent objection, raised long ago by Mivart, is this: that many characters easily recognized to be very useful to the individual and hence easily conceived to be the basis of selection

on account of their usefulness, are so, however, only when they have become perfected, and are of no use, and hence have no selective value, in their incipient states. Many such examples occur to anyone: the electric organ of the torpedo fish, for instance, or the cameleon's tongue, or, to use an even more vital illustration, one to which Kellogg (l. c.) calls attention, that classic example of all evolutionary writers, the mimicry of one insect species by another. We have two kinds of resemblance that must be recalled, one, the general resemblance by virtue of which an animal resembles its whole environment, as a white fox on the snow, or a lizard on a sand-bank; and the specific resemblance which we call mimicry, in which the animal, usually an edible insect, imitates another inedible species in the finest details, and thus escapes destruction by its natural foes. Think a moment and you will see that for such a resemblance to have any influence in the struggle for existence it must be all or nothing; an approximation would not be of any value, yet by the Darwinian hypothesis such a final form must have been reached by the gradual elimination of minute variations, each of which would have selective value, so that in the end a typical mimetic form would remain.

Perhaps the most vital objection of all is this: that fluctuating variations, which are the only kind considered by Darwin, are always confined to plus or minus changes in something already existing. Consequently the progress of such variations must always be linear. They are quantitative, that is, and not qualitative. For instance, an appendage may on the basis of such variations become longer or shorter, heavier or lighter, but the appendage must previously exist before it can vary in this way; fluctuating variations cannot explain the original appearance of the rudiment. Nothing is more evident than that evolution is polygenetic and qualitative, so that it would seem necessary, even if natural selection is the basis for the development of new forms, that some supplementary influence should intervene at the proper time to produce qualitative differences for such variations to work on.

One other development of the study must be mentioned: it has been established, first by Kropotkin and later by others, that the struggle for existence about which so much has been said, while real enough, no doubt, is not so universal as previously suggested.

First, the factor of what has been called "mutual aid" must be taken into account, the development of the social instinct and the superiority of a species,—say of bees,—in which a social organization is perfected, over a species of solitary bees, such that advantages accruing through merely fluctuating variations of the individual would be of very little significance in comparison with the advantage gained through co-operation. Second, it will be readily seen that the competition, real as it is, between the hosts of individuals born into the world is thoroughly over before sexual maturity, as for instance in the May-flies, which spend a year or two as aquatic larvæ and then emerge for a few brief hours of adult life as winged insects. It will be readily seen that if adult characters are used as a basis for selection, the "struggle for existence" in this case, and the resultant selection as individuals must have been over and done with before metamorphosis, (omitting of course all reference to sexual selection). Third, among the lower forms, accident probably plays a very much larger part in the elimination of individuals than competition. To quote Kellogg¹⁰: "What shall decide, when the big whale opens his mouth in the midst of a shoal of myriads of tiny Copepods floating in the pelagic waters of the Aleutian seas, what Copepods shall disappear forever? Mainly, we may say, the chance of position. A bit more or less of size, or strength, or redness, or yellowness, or irritability, or what not, of form and function, is going to avail little when the water rushes into the yawning throat. Now this chance and this luck are the luck and chance of the law of probabilities; that is, luck and chance capable of being mathematically determined. Given so much ocean, with so many whales swimming about in such and such curves at such and such rates and opening and closing their mouths intermittently at such and such intervals, and just so many shoals of so many million Copepods, these shoals at such and such distances apart, and any mathematical friend will reckon for you the chances any one Copepod individual has at any given moment of being swallowed. But Darwinian variations in the Copepod body will be represented by no function in the mathematician's formula." And Wolff¹¹ has somewhat humorously called attention to the fact that the fate of millions of tapeworms

10. Darwinism To-day.

11. G. Wolff, Beiträge zur Kritik der Darwin'schen Lehre.

may hang on a speech made in the Reichstag concerning the inspection or limitation of the importation of meat.

You will have noted that all these objections are in the way of destructive and academic criticism, seem to be faultfinding, so to speak; and it must be said that for most of the points mentioned, the latter-day exponents of "Darwinismus" have a more or less appropriate reply. Experimental Biology, however, has made certain contributions to the subject that force a re-statement of the original Darwinian position and in the minds of many compel an abandonment of the selection hypothesis as an explanation of the Method of Evolution. Chief among these have been the results of animal and plant breeding. Beginning with Galton and continued by others, the principle of regression has been emphasized. That is, not even by artificial selection can the type be indefinitely moved from its center of stability.

Within the past few years Johannsen¹² has conducted extensive experiments in breeding beans, and Jennings¹³ in rearing *Paramecium*, one of the one-celled microscopic organisms commonly found in stagnant water. The advantage of both of these types is that in the care of the beans the flowers may be self-fertilized, and in the case of the *Paramecium* reproduction occurs by direct fission of the parent organism into two. In both cases the progeny of any one individual may be kept separate without the introduction of unknown factors through the cross fertilization or mixing of two strains, necessary with most animals and plants. Both these observers found that the progeny of each individual showed a range of variation, which could be plotted in a curve, but that selection from this lot did not alter the curve, i. e., it was impossible to vary the type by selection, for the reason that by something intrinsic in the nature of the race it regressed or reverted to the norm of its derivative. The progeny of each individual differs from another, and these have been called genotypes or pure lines. The species itself has been made up of numerous genotypes of this kind, which by constant crossing or hybridizing one with another have produced an apparently greater range of variation for the whole group (the phænotype). Now, it is apparent that selection (natural or arti-

12. Johannsen, W. "Über Erblichkeit in Populationen und in Reinen Linien," 1903.

13. Jennings, H. S. *American Naturalist* 1909, v. 43, 321 and elsewhere.

ficial) from the mass of the race can do nothing more than isolate individual pure lines, which are in themselves capable of varying only within narrow limits, and hence incapable of providing that adjustment to a changing environment which brings about the formation of a new species. This is, after all, merely the experimental proof of the conclusion previously reached on a priori grounds, that selection cannot create, but can only modify.

Secondly, whenever a biologist has had an opportunity to study a large series of forms, particularly wherever the rocks have afforded the past history of some one type, like that of the Ammonites, it has been evident that variation as expressed in the succession of forms in time has not been haphazard—now in this direction, now that—but has steadily followed a line of progress. It has, in other words, been *directive* or Orthogenetic variation, and whatever the nature of the *internal perfecting principle* at the bottom of it (about which we know nothing at all), it is certain that in these cases the mechanical explanation of Darwin is too easy, too naive, and does not accord with the facts.

In the third place, Tower has shown in experiments on potato beetles that various sorts of bizarre types, apparently permanent in their heredity, may be produced by the direct action of environmental stimuli, provided the environmental stimulus be applied at a time when the germ cells are maturing and when apparently the germ plasm is relatively unstable. The direct action of the environment in producing new types must be denied, by hypothesis, by thorough-going Darwinians, altho conceded by the Lamarckians.

For all of these phenomena, fundamental and unsettling as they are, we have not a glimmer of understanding or of explanation. Whither, then, shall we head our bark, we who have held so long to the star of Natural Selection? Shall we drift idly on the sea of speculation, or shall we stop rowing? As this is a college rather than a nautical audience, let me vary the figure. Those of you who have watched a foot ball game may often have seen times when the ball was being steadily and uninterruptedly advanced down the field; then all at once there would be a fumble and the ball would be lost. In the scramble no one seemed to know where it was, under the mass of men. When this happens it isn't customary, however, for the players to retire to the side lines and declare the game off.

Neither do they start all over again. But the referee marks the spot and all line up for a fresh scrimmage.

In attempting to solve the riddle of Evolution, biologists may perhaps have temporarily lost the ball, but they have, by no means, lost the game.

To come again to plain statements, the recent pamphleteers who seem to think that there is no alternative between Darwinism and Genesis¹⁴ may well be counselled to read some of the contributions to evolutionary literature of the past twenty years in order to properly ballast their zeal with facts. These contributions may safely be said to have had no influence whatever in crumbling the foundations of Darwinism. The real attack has come from within and only from those with eyes "single to the truth" like Darwin himself, and who follow the truth as they find it, no matter where it lead them.

A couple of years ago the scientific men of all nations and classes gathered together to celebrate the semi-centennial of the publication of a book, and wherever groups of any size could assemble symposia were held, in which the influence of that book was discussed, the author's views analyzed and compared with present day opinions on the same subjects. Some of the criticisms were laudatory, some were adverse. Well known men, in discussing the same point, frequently took opposite sides, but it never occurred to any one to question the preeminence of that book as a landmark of intellectual progress, something to measure by and to date from. The book was Darwin's "Origin of Species", and it was not without significance that biologists should estimate its worth in such fashion, for it has been my personal experience that outside the ranks of professional scientists, a goodly number of those who unhesitatingly endorse the "Origin of Species" and the doctrines that it stands for, would be quite unable to say whether the work was written in prose or in blank verse.

In conclusion, let me quote Huxley, from an address written in 1880: "History warns us that it is the customary fate of new truths to begin as heresies and to end as superstitions; and, as matters now stand, it is hardly rash to anticipate that in another twenty years the new generation, educated under the influences of

14. Wolff refers to "the episode of Darwinism" and suggests that our attitude toward him should be "as if he had never existed." (Quoted by Kellogg.)

the present day, will be in danger of accepting the main doctrines of the Origin of Species with as little reflection as so many of our contemporaries twenty years ago rejected them. Against any such consummation let us all devoutly pray; for the scientific spirit is of more value than its products, and irrationally held truths may be more harmful than reasoned errors. Now the essence of the scientific spirit is criticism. It tells us that whenever a doctrine claims our assent we should reply, 'Take it if you can compel it.' The struggle for existence holds as much in the intellectual as in the spiritual world. A theory is a species of thinking and its right to exist is co-extensive with its power of resisting extinction by its rivals."

Honest Biologists will tell you today that Darwin's hypothesis has proved inadequate to explain all the phenomena that must be explained if it be a universal key to the riddle of evolutionary progress. But that it does explain much that is otherwise inexplicable no one can deny. That it is the most useful tool fashioned by the intellect of man since Lavoisier's generalization of the Conservation of Matter or Newton's "Law" no one will deny either. And if in the progress of knowledge we finally outgrow its use altogether, yet Darwin will continue to stand for all time, second to none among those whose labors have helped to free man from the shackles of superstition and helped him toward that larger freedom of thought which we like to think makes for man's greater happiness and betterment.

NOTE: In addition to the references mentioned in footnotes, the following works are valuable in getting a viewpoint with respect to the modern critical attitude toward the Selection Theory.

HESSE, R.

"Abstammungslehre und Darwinismus." Leipsig, 1908. (Popular exposition, pro and con).

LOTSY, P.

"Vorlesungen über Deszendenz Theorie." I and II Teile (pro-Darwinian).

POULTON, E. B.

1908. "Essays on Evolution." Oxford, (pro-Darwinian).

1909. "Darwin and Modern Science". 29 essays by specialists in commemoration of the centenary of Darwin's birth. Cambridge.

1909. "Fifty years of Darwin." Centennial addresses (referred to above). Holt, N. Y.

RADL, E.

"Geschichte der Biologischen Theorien." II Teil (anti-Darwinian).

ERRATA

Page 17, paragraph 3, line 2, *Maupertuis*.

Page 23, line 4, *stands* for *stand*.

Page 24, paragraph 5, line 7, *once* for *one*.

Page 25, paragraph 2, line 5, *rank* for *rack*.

Page 27, line 2, *Quetelet's*.

Page 30, paragraph 2, line 5, *case* for *care*.

Page 32, last line, *physical* for *spiritual*.

Page 33, Bibliographical note: the last two references under Poulton's name should not be so included. They are independent collections of essays by various authors.